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## REPORT

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## Chapter 13. MILITARY-GEOLOGICAL MAPS AND METHODS OF CARTOGRAPHY

[Figures referred to in the text are not reproduced but are available in the original document at the US Geological Survey.]

### A. General Information

In those cases where, for the study of a locality from the military-geological point of view, it is not possible to make direct observation due to conditions of the military situation, it behooves the military geologist to make prior use of geological documentation which has already been prepared. The experience of World War II showed that the previous preparation of specialized military-geological maps and accompanying gazetteers makes possible the assembling of data on a locality which is necessary for working out plans of strategy, the execution of various operations, and the different kinds of engineering work connected with the solution of the tactical mission. Such data on the climatic, hydrographic-hydrological, geomorphological, geological, hydrogeological, and soil conditions aids the command in the conduct of an engagement and in the execution of any engineering measures. It permits judgment to be made beforehand of the requirements of technical equipment and manpower, and makes possible the establishment of dates for the completion of the various phases of the work. Furthermore, such data considerably facilitates military-geological surveying (razvedirovka) and prospecting (tasyudka).

When military-geological surveying and prospecting are not possible, the prior compilation of military-geological maps and gazetteers constitutes the only geological data with which either the officers of the various branches of the armed forces or the military geologists can start.

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The value of such documentation for officers is determined, aside from the promptness with which it is received, by the completeness of the data presented in it, and by its fitness for use. It must be drawn up concisely, on the principle: "Everything necessary and nothing superfluous."

Utmost clarity and brevity of documentation are achieved by graphic representation of any data in the form of maps, sections, diagrams, etc.

The greatest advantage of military-geological maps is the convenience they afford in appraising any military situation in a geological respect. Finally, on maps and sections it is easy to correct the results of newly obtained data from military-geological surveying and prospecting. Therein lies the advantage of military-geological maps and sections in comparison with verbal material.

At the same time, military-geological maps are to a certain extent schematic, because their make-up is bound to take the form of cartographic generalities, due to the impossibility of transmitting all geological information with the desired exactness, especially in small-scale maps. Therefore, the principle of "essential representation" of data having the most practical significance must be especially strictly observed in military-geological maps. The content, completeness, and fullness of military-geological maps is determined by their scale and purpose.

In this connection, before describing the types of military-geological maps, we take up the basic types of topographical maps used by the armed forces.

#### B. Military Maps

Depending on their purpose, military maps are divided into tactical, operational, strategic, and special.

Tactical maps belong to the category of large-scale maps (1: 100,000 and larger) which permit orientation on the battlefield (an area of from a few to dozens of square kilometers). Such maps are intended for the commanders and staffs of small military units.

Operational and strategic maps belong to the category of small-scale maps (smaller than 1: 100,000) permitting the important part, according to the size of the territory, to be encompassed. Such maps are intended mainly for the staffs of large units (groups).

The scales of the different types of military topographical maps are as follows:

Tactical maps are of the scale 1: 100,000 and larger. For sparsely inhabited places, maps of 1: 200,000 scale are sometimes used. The scales of tactical maps are chosen according to content and purpose.

Maps of 1: 10,000 scale (sometimes larger) are "positional," for the territory adjacent to the zone of operations. Maps of this type are used for the execution of operational tasks by airborne units, army aviation, etc.

Maps of 1: 25,000 scale are the basic tactical maps in positional warfare and are used as firing maps.

Maps of 1: 50,000 scale are considered the basic tactical maps in warfare of maneuver during large offensive and defensive operations. They are prepared in advance and in large sizes.

Maps of this scale constitute also the maps of concentration of reinforcements in positional warfare.

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Maps of 1: 100,000 scale are the basic tactical maps for large mechanized or cavalry corps. They also replace the basic tactical map for the other branches of the armed forces in engagements and in the conduct of military operations in uninhabited regions. At the same time, they serve as large-scale operational maps.

Operational maps of 1: 200,000 to 1: 500,000 scale facilitate any decision by a commander and staff during preparation of combat operations and execution of those decisions. These maps serve to provide orientation during combat operations of large armed units and for the general accounting of material resources supplying the course of operations in the battlefield.

Among operations maps the following types may be distinguished:

- 1: 200,000 scale maps - concentration maps, compulsory for staff and troops;
- 1: 500,000 scale maps - general operations maps for all combat theaters;
- 1: 1,000,000 scale maps, which usually constitute the basic map for the various specialized operations maps.

Strategic maps (of less than 1: 1,000,000 scale) serve for the general study of the combat theater. Depending on the size of the combat theater and the degree of knowledge concerning it, the scale of these maps may be 1: 1,000,000, 1: 1,500,000, 1: 2,500,000, up to 1: 5,000,000.

For USSR territory, the German fascist army used tactical maps of 1: 25,000 scale (Poland, Lithuania), 1: 50,000 (Moscow), and 1: 100,000 (Poland, Lithuania, Russia), but their operations maps and air force maps were on the scale of 1: 300,000 (Eastern Europe), 1: 1,000,000, and 1: 2,000,000. There are tactical maps for German territory on scales from 1: 5,000 to 1: 100,000.

With contemporary modes of warfare, topographical maps alone prove insufficient. Special maps exist. They likewise have different purposes and accommodate special branches of the armed forces: aviation or "poletnye" (TN: airborne?) artillery, tank, and others. Among specialized maps belong railway and supply maps, and survey maps, which contain other information of a narrowly specialized character and which have significance in the conduct of combat operations or in the preparation for them. In this category also belong economic, political, military-geological, and several other types of maps.

### C. Military-Geological Maps

These maps complement the general military maps (tactical, operational, strategic) but also have independent significance in the preparation and execution of combat operations and military-engineering measures.

The necessity for military-geological maps arose during World War I as the natural consequence of the development of military techniques and modes of warfare. Geologists' work in this direction began as early as the spring of 1915 in all armies, but especially in the armies of the Western European front. By the summer of 1916, the new and, practically speaking, very important field of military-geological cartography was established.

During World War I a great quantity of specialized geological maps, which became the basis of various military engineering works, was accumulated. The methods of their compilation were being determined in different ways by the various belligerent powers and even by the various armies.

Even though certain changes were made in these maps in which specialized, geological symbols (indices) and terms were replaced by simpler, more practical concepts, the delineations of geological strata were still shown on the basis of stratigraphical principles, and the maps did not answer practical needs. Only later, when they began to represent strata of one given exposition and return by one general symbol without regard to its age, was the new type of map, which was suitable for the armed forces and for many practical purposes created.

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The most successful maps were those, made for specifically designated purposes, in which only those geological peculiarities of a region which might influence the execution of a given phase of an engineering task were shown in readily legible and graphic form. All matters of secondary importance were either omitted entirely or were shown in much less detail. Maps with such geological, hydrogeological, and other information gave rapid and sufficiently full and specific answers to this or that series of questions.

Inasmuch as maps which permit only one interpretation of data are read most quickly and easily, it is natural that those which show only geological data with practical significance for one, two, or, at the most, three aspects of an engineering task enjoyed the greatest success.

As practice has proven, it does not pay to assemble all geological data necessary for military aims on one map for practical use by the armed forces, even though the attempt to prepare that kind of map has been made many times. Such collated complex maps, or as they are sometimes called, "survey maps," were prepared at the very beginning of World War I.

The scale of these maps is from 1: 200,000 to 1: 500,000 or smaller. They make it possible to draw conclusions of a general nature in the solution of operational and strategic questions.

Later cartographers progressed to the preparation of specialized military-geological maps for diversified field purposes: maps of geological conditions for fortification operations, maps of geological conditions for underground mine warfare, water-supply maps (maps of water utilization, maps of water pipes, etc.), maps of the region's traversability for tanks, maps of the geological conditions for hydrotechnical operations (creation of water barriers), maps of marshes and lowlands, maps of the geological conditions of the region, maps of drainage, high water, and floods, maps showing difficulties of using the ground for military-engineering constructions, maps of the ground conditions for the selection of artillery positions, soil maps, maps of landslips and avalanches, maps of the various effects on the ground of shells and bombs, maps of the geological conditions for gas attacks and antigas defense, maps of geological influences on telegraphy and radio-telegraphy, maps of magnetic declination and anomalies, maps of strategic minerals, various useful minerals exploited for military ends, maps of on-the-spot, mineral construction-materials, maps of the layers of mineral dyes, etc.

The scale of these maps depends upon their specific purposes. For example, the scale of the traversability, water-supply, and mineral construction-material maps may be either large or small (1: 500,000 or smaller), but more often, specialized military-geological maps are of large scale, from 1: 100,000 to 1: 5,000. They afford the possibility of evaluating the geological situation with great accuracy. The most useful maps for practical purposes in World War I proved to be those of 1: 25,000 scale with representations of the interglacial, quaternary formations, the so-called "non-uncovered /concealed/ maps."

On such maps all information is shown in a form readily legible to officers, i.e., not in the form resulting from the usual geological observation but giving only appropriate conclusions and generalizations from these observations, most often with specific recommendations, in which the stratigraphical and genetic indexing were sometimes preserved for geologists.

The most convenient form of explanation proved to be tables which were applied to the map. In these tables, located on the same sheet as the map or separately, were summarized the most important data for military purposes. The table for the preparation of the position before Stanislaw (see Table 38, appended may serve as an example.

In order to show the geological features in a more or less depressed

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lowland, sections are frequently made which have proved quite necessary for some purposes, particularly for mine warfare. The sections were located alongside the maps on the same sheet and only rarely were issued separately. A particular form of geological sections used in conjunction with topographical maps enjoyed great popularity among the armed forces. The sections were placed on the topographical map corresponding to it along appropriate lines. The nature of the strata which had military significance was shown in colors. Dry strata, suitable for mine operations could also be distinguished on the sections.

The use of the complex survey-type of military-geological map grew greatly during World War II, but the need for specialized military-geological maps grew incomparably more. The present store of maps of this type has changed little since the past World War, but the contents of certain types of specialized maps has changed.

Without considering military-geological maps published in USSR, we cite below the basic types of military-geological maps which have reached the widest circulation in almost all contemporary armies. Among the most important are the maps which show traversability of terrain, conditions of army water supply, and layers of mineral construction-materials, and also maps which characterize the geological and hydrogeological conditions for the erection of fortified constructions.

#### D. Maps of the Traversability of Terrain

In World War I, geological and other maps were little used for the evaluation of the traversability of terrain, basically because of the lack of preliminary gathering and interpretation of pertinent geological and hydrogeological data. In literature on the subject, however, there are references to such a type of map. This, for example, in the beginning of 1917, the French Fifth Army issued a map of a part of the Rhine sector on a 1: 80,000 scale, in which there was given a classification of superficial geological deposits according to degrees of their traversability in the dry and wet seasons of the year.

A traversability map of larger scale (1: 20,000) is known for the region where the French Third Army was stationed (Fig 92). That map was very primitive, but it was nevertheless, used successfully by the army. The project of a whole series of specialized tank maps was worked out by the French Geographical Institute, but apparently not a single one of them was ever published.

The British had maps which contained an extensive classification of the territory of the whole front according to the degree of traversability of the different regions, wherein a characterization and evaluation of the possibility of tank utilization was given for each region.

It is possible to establish from certain German specialists that the German Army attached especially great importance to traversability maps during offensive operations. According to Seidlitz, in many cases, the Germans based their tactical plans of operations in certain regions almost entirely upon information derived from that kind of map showing the traversability of a given territory. It is known that in the autumn of 1918, survey tank maps were drawn up for all Flanders, in which the regions which were suitable for the construction of water barriers and the widespread regions of dry sand and clay which were better suited for the construction of dry tank traps and for laying tank mines could be distinguished.

Furthermore, for this same territory of Flanders, special maps of the canals, showing the characteristic permeability of the ground and the canal walls' resistance to bombardment, were drawn up.

Geographo-morphological (T.E. contour) maps, also called "regional maps," are often used, too, to evaluate the traversability of a terrain. They show all

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the relief features which are most characteristic and important from the standpoint of traversability, such as: plateaus, lowlands, steep precipices, river basins, thick networks of gullies of very difficult traversability, marshy sectors, periodically flooded sectors, and dunes. For regions of roughly broken land, special survey maps were prepared in various colors or tints, in which the different elevations were indicated by different colors. For the plains region of the Russian (Eastern) Front, a very clearly differentiated character was usually given in traversability maps to swamps and marshy land, flooded and particularly menacing sectors of uncontrolled rivers, etc.

It is worthy of note that for the region of operations of the German Seventh Army, special "swamp maps" were issued.

These maps brought out clearly the various bog depths by classification of up to 50 centimeters, 2 meters, and over 2 meters. They also showed clearly the places of possible passage for infantry, cavalry, artillery, vehicles, armored cars, and tanks, and the most suitable sectors for the installation of positions by contours and special signs.

It is evident from the experience of World War II that the problem of terrain traversability continued to grow in importance and that special traversability maps prepared beforehand are necessary for use on the front, since the data of traversability given in military topographical map is far from complete.

An estimation of terrain traversability must be made in the elaboration of plans of strategic operations, in the solution of operational-tactical problems for all types of troops, and even for each kind of troops separately, in fortification operations, in the arrangement of all types of defensive lines, resistance centers, etc.

The traversability of terrain is not the same for tanks and motorized-mechanized artillery units as for infantry, and depends largely upon the technical equipment of an army and on the inherent situation, the time of year, etc.

At the present time there exist several forms of traversability maps. Besides the small-scale survey maps, which were so widely used by the staffs of large units (groups) in working out operational or operational-tactical problems, wide use was made by the armies of the various sectional maps, which as a rule were made on a larger scale and in greater detail. Such specialized sectional maps include tank-traversability maps, maps for negotiation of water barriers for the various branches of the forces, maps of roads, paths, bridges, water crossings, maps of bad roads caused by seasonal rains (conditions of traversability of the terrain and of the roads in the bad season), maps showing inundation and marshiness at high water, maps of the traversability of swamps, meeklands, estuaries, and negotiation of mountain passes.

As traversability conditions change greatly, depending on the time of year, climatic peculiarities, etc., these maps in the majority of cases are composed, like forecast maps, of such-and-such traversability conditions in specific seasons.

Information on terrain traversability is worked up in various ways in the various types of maps. The methods of preparation of these maps are not in the least standardized. On the small-scale, survey, traversability maps, the whole territory is worked out more or less equally, and information concerning all basic factors is shown for the traversability of specific terrain, such as: relief, hydrographic network, soil layers, vegetation covering, road networks, bridges, water crossings, unfavorable physical geological features, climate, all kinds of artificial obstacles, etc. On maps of this type, the

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division into districts is almost always carried on by a code of signs. On the large-scale, specialized, sectional maps, as a rule, the area is worked out in unequal degrees of detail, i.e., only the data which has practical significance for the given type of map is shown. For example, it might well be that on a map for negotiating water barriers, no light at all is thrown on the problem of the traversability of a nearby mountain pass, and vice versa.

Information on terrain traversability is also found on small-scale geographic-geological maps. Fig 93 shows a captured German military-geographical sketch, issued in Germany in 1941 shortly before the treacherous German fascist attack on the USSR. By various conventional signs, this map distinguishes regions differing from each other in soil conditions, and for each region the legend gives a short, very general characterization of the peculiarities of relief features, of the hydrographic network, of swamps, of forested areas, of the depth of the water table, with a general evaluation of the terrain traversability and its seasonal variations. Isolines set off zones of equal duration (in months) of frost, and particular contours are used to set off areas of deeply cut ravines and gorges and sections rich in outcropping rock layers. Detailed explanations and characterizations are given in a special supplement to the map. Sometimes traversability maps give only data lacking on large-scale topographical maps, which nearly always show relief features, hydrography and road networks. In such cases a diagrammatic traversability map complements the topographical map to form one integer with it. Such maps show the areas occupied by soil, marshes, forests of varying degrees of traversability, and they set off terrain characterized by special conditions of traversability, as well as sections susceptible to inundation.

More detailed descriptions of the various regions are given in special tables of traversability factors, in which the influence is pointed out of the separate factors of traversability upon the movement of the various types of transportation and various kinds of forces in dry, rainy, and winter weather. Frequently information is presented concerning the regions' provision of road materials and water.

## F. Water Supply Maps

Problems arising in the organization of army water supply frequently have to be resolved without making hydrogeological investigation. Under war conditions even in the best cases it is not possible to receive more than a small part of the necessary data when gathered on the spot by specialized engineering surveying and prospecting.

Most often it is necessary to supplement this with previously prepared material elucidated in maps and reference books.

The data required for army water supply is of very diversified nature. Therefore, it is not always possible to reflect it all in one readily legible map. In the predominant majority of cases, water-supply maps are composed separately from the other types of military-geological maps, and only occasionally are they combined with some of them, as, for example, with fortification construction maps, with maps of hydrogeological and hydrotechnical data, etc. Frequently, for a given region, several types of water-supply maps, of different contents and different scales, are prepared.

In contrast to all other types of specialized, military-geological maps, the contents of water-supply maps have changed very little from the time of World War I. Therefore, that rich experience which was gained during the war period, 1914 - 1918, is of great practical interest for the compilation of water-supply maps at the present time. In the majority of cases in water-supply maps, the greatest attention is given to information concerning existing water points, the most easily obtainable shallow-lying water, and water tables.

In World War I, the American and British Expeditionary Forces paid

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especially great attention to the characteristics of water tables. The American Army's "hydrogeological maps" and "water-supply maps" gave the volumes of rivers, showing the usual mean and minimum, and less often, the maximum.

It must be noted that in establishing the volume of rivers, especially rivers lying in enemy-occupied territories, many difficulties always arise. Often it is to be observed that even the very experienced hydrotechnical engineers cannot always forecast the possible volume of a river. According to Brooks, many unsuccessful attempts were made by the American Army, and geologists relieved more successfully the work of estimating the resources of superficial water and of forecasting the volume of rivers.

Drying-up segments of rivers, rivulets, springs and wells, just as very voluminous wells, water holes, and springs were designated by particular symbols on American maps. In the case of a group of water points, their quantity was indicated. Furthermore, the presence of water-distributing stations, pumping works, water-piping systems, ponds, etc., was noted by letters on the maps.

In Brooks' opinion, the practical significance of maps of this type would have been greatly increased if the depth of the principal water table had been shown on them.

In the explanatory notes to the maps, there was always an alphabetical list of the inhabited points with a complete indication of the water supply.

Similar material was issued also by the British Expeditionary Force. In the explanatory notes to these maps, in addition to the sources of water supply of each region and the alphabetical indication of water supply of the inhabited points, the type of mechanical equipment necessary for drawing water was also usually shown.

For enemy-occupied territory, such maps were prepared for each of the various regions, according to the type of water-supply source.

These maps served not only for strategic purposes but also to enable the forces to choose and prepare in good time the appropriate technical means which would be required in the organization of water supply in offensive operations.

The following extract, quoted by Brooks, from the explanatory notes gives an example of the nature of the information contained in this type of map:

Area I. Plenty of surface water. Water of H-canal is bad in flax-retting period. Small wells a few meters deep will supply horses in any low-lying place.

Drinking water: Small quantity. Utilization requires sterilization (either by alum treatment or chlorination). Drilling not practicable because of Tenetok [3] sand (the deepest Eocene stratum). Water salty.

Necessary equipment: Only hand pumps, equipment for sterilization of containers or conveyers. Alum treatment installation.

Area IV. Clay, lying on Tenetok sand over ancient strata. Springs in the valleys at points of contact with ancient strata. Some quantity of water was obtained from the Tenetok sand by drilling. Sufficient surface water for horses.

Necessary equipment: Surface pumps for springs. Pumps for piped wells without air lifts. Ashford [Rechford 1] steam engines.

Area XV. Colite limestone covered with clays and sometimes with sands.

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A small quantity of springs in the valleys from the limestone, but in general the locality is dry. Drilling did not extract water from sand.

Necessary equipment: Surface pumps and pumps for piped wells.  
Air lifts.

For strategic and tactical purposes, the English likewise issued hydrogeological maps of enemy territory by districts. The quantity and quality of water of the various regions was taken as the basis for separation into districts. They took as the unit of measurement a quantity of water equal to 500,000 liters, which might be obtainable from an area of 50 square kilometers. Regions of abundant, medium, or slight water resources were designated by different colors. In each region, in turn, areas of good and bad water were marked.

The French armies separately issued maps on which the distribution of sources of water supply, specially adapted for military needs within the limits of their positions, was shown.

In almost all countries, water-supply maps were large-scale maps. They were provided with brief explanatory texts or tables. On the maps and in the texts was recorded all information concerning existing or possible water sources, including springs, wells, reservoirs, water pipes, cisterns, rivers, lakes, ponds, and subterranean water accessible for use. The greatest significance was attached to data concerning the quantity of water, but its quality was also noted. Especial attention was paid to seasonal fluctuations in the volume of superficial streams and levels of subterranean waters.

Among the first German hydrogeological maps was the water supply map of Army Group S (of Strass). The map was made on the scale of 1: 50,000 on the basis of one and a half year's systematic observation of the wells and sources. Such hydrogeological maps, as well as specialized maps of subterranean water, were compiled in the other German armies of the Western Front. The different methods of obtaining water, depending upon the hydrogeological conditions of the region, were distinguished on these maps. Conventional signs were used to note also the possibility of drawing water from wells, with allowance made for existing consumption.

Most important for all hydrogeological maps is the information concerning the depth of the water table and the possibility of seasonal fluctuation of its level. Such maps were often used in combination with maps of fortification construction and underground mine laying. For areas of variable water-table level and for areas with few water-supplying strata of practical value, these maps showed the disposition of the second and even the third water-supplying strata. The direction of the water's flow was represented by the aid of hydrostructure contours. A map on a scale of 1: 150,000, compiled for a part of the Cambrai-Lille sector, may serve as an example of that type of map. It is suitable not only for the resolution of the water supply problems but also in elucidating the conditions of underground mine laying and fortification construction (see Fig 96).

Where there was a broken or unreliable layer as the first of the shallow-lying water-supplying strata, it was usually represented with crosshatching. The fluctuation of water table was most often shown in profile.

Water-supply maps were compiled on the basis of such a type of map showing the disposition of subterranean water. Apart from the distribution of "outlets" or subterranean waters and areas of prevalence of deep or shallow water tables, indications were given of the quantity and quality of water of the various sections (including hygienic properties).

For each town and inhabited place there was presented a quantitative and qualitative characterization of the water supply conditions and of all

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systems of military water supply, including reservoirs, pipe lines, and water towers.

The most highly regarded example of this type of water-supply map was the one for the vicinity of Cote-Lorraine (north of the city of Metz), on the scale of 1: 50,000 (later re-issued on the scale of 1: 25,000). To a map of this type were added specially published instructions, with graphic diagrams of the most expedient methods of water supply: the construction of wells, the execution of the deepest drilling, and methods of damming or harnessing streams. In the beginning, these instructions were printed on the reverse side of the map, but later they were both issued separately.

On these maps one could distinguish the sectors of shallow or deep wells and the inhabited places where troops were safe from water-supply dangers. It was also indicated how many troops might be billeted in this or that town or village. Points where high frequencies of typhoid or other illnesses connected with faulty water utilization had been observed were particularly noted.

Great importance was attached to maps of the water piping of inhabited places. Thus, maps of the water systems of the cities of Calais, Dunkirk, and Boulogne were prepared by geological organizations on the basis of existing data available from literature on the subject together with information gained from aerial observation. There are existing indications that in forward positions, line troops likewise used special maps of hydrotechnical operations, on which points of present or possible water consumption were marked by particular signs, with indications of volume of output and all types of hydrotechnical measures. On being withdrawn the troops handed these maps over to their relief.

Fig 97 shows a German water-supply map, scale 1: 25,000, published after World War I, which in the opinion of German specialists, proved to be one of the most successful.

This brief survey of the water-supply maps of World War I and the experience of World War II show that for the organization of army water supply, information concerning existing sources of water with the output volume of the most productive sources is of prime importance.

Also of very great practical interest is information concerning the possibility of increasing the productivity of water sources, the necessary measures for its accomplishment, and the relationship of available means of drawing water to the productive capacity of the water sources. Whenever springs are concerned, information concerning the most rational types of damming (or harnessing) is of great importance, but for zones with outcroppings of water-bearing strata, information concerning the types of water-retaining constructions is particularly important.

Of no less importance is data concerning water pipes, water-conduit systems, all types of reservoirs and water-supply tanks, equipment of water holes (including surface equipment), data concerning purifying constructions and installations, sources of pollution, etc.

At the present time, the widest variety of types of maps of diversified content and scale is used in the solution of problems connected with the appraisal of water resources and organization of water supply. Examples of these are military hydrogeological maps, maps of available sources of water supply and water consumption, water procurement, etc.

If it is impossible to show on military hydrogeological maps all the data necessary for the solution of practical problems of army water supply, special maps of the water supply of inhabited places are prepared, with indications of the quantity of water points, depth of water level in wells and water holes, volume of water in wells, and maximum possible water withdrawal

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in cubic meters per 24 hours from all water points.

Most often this information is given in special tables located on the margins of the map. On the map itself, only the size of the inhabited places is marked. Sometimes particular symbols are given for the inhabited places depending on the predominant type of water points. Frequently such a map shows margins of prevalence of water tables at varying levels, the water points lying outside the inhabited places, and the volume of rivers and brooks. Such maps permit speedy determination of the water-supply security of an army in any disposition of forces, and of the location and quantity of necessary and new water points. They also permit the preparation at the proper time and in necessary quantities of the technical means of water extraction and purification.

#### F. Maps of Emergency Mineral Materials for Construction and Camouflage

Of all types of specialized military geological maps the most frequently required are maps of emergency mineral materials for construction or camouflage, with information concerning the location and suitability of strata for specific military purposes, information concerning the stocks available and the conditions determining their exploitation, information about quarries and other depositories, convenience of accessibility to them, etc.

Such data is given on maps of the various useful minerals and on maps of mineral construction materials and mineral raw materials for dye-making. Some information is available from geological, lithological, and engineering-geological maps prepared for various purposes in time of peace. However, the experience of past wars and especially World War II teaches us the necessity of preparing specialized maps of emergency construction and camouflage materials, since the information on sand, gravel, stone, and camouflage materials in the previously mentioned types of civil maps was usually very limited and often proved to be obsolete.

Such specialized maps were of the small-scale, survey type for staffs of large army units (groups), and the more detailed large-scale type was for immediate use in indicating places and conditions of exploitation of emergency construction and camouflage materials. The above-mentioned maps are best composed on the lithological basis. Areas or points where, in time of combat, installations may be set up for exploitation of strata suitable for the extraction of construction material are set off by special symbols. The maps show all existing and abandoned open pits, stone quarries, mines, lime kilns, brick factories, stationary gravel-washers, stone crushers, etc.

More detailed information of the locations is given in special tables which are either located on the margins of the maps or are issued separately. In the war of 1914 - 1918, maps of construction materials on various scales from 1: 420,000 to 1: 75,000 with reference tables were prepared early and issued to the Russian Army.

In the prosecution of World War II the most worth while were the construction material maps with tables giving the most important data for practical purposes for each location: the composition, nature and suitability of the strata for specific purposes, the productive capacity of the deposit, the available supply, the capacity and composition of the cappings /top layers/, the amount of water present, the conditions of exploitation and accessibility.

In conclusion, it must be noted that in World War I and II a complex type of map was used, which was known as "engineering geological" or "military geological." On these maps, with a lithological basis, the nature of the strata and the amount of water present was clearly brought out. A large share of the information was devoted to servicing the various types of military construction, fortifications, underground mine laying, military roads, airfields, military hydrotechnical works, etc. However, the small scale of

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such maps (1: 500,000, etc.) does not permit representation of all the necessary data; hence, their use by troops and in the construction of defensive military objects is limited. They are good as reference aids for specialists and military men familiar with the application of geology and the various branches of military engineering.

For the solution of various practical problems of fortification construction, underground mine laying, and the like, it is ordinarily necessary to construct specialized maps on a larger scale. For example, for mine-laying operations, specialized maps of scale 1: 25,000 and 1: 10,000 are used. Fig 38 shows a large-scale map (1: 10,000) composed by the English for the sector of the famous mine battle of Witshaete [Witshaete (?)/ Witshaete (?)] in the war of 1914 - 1918.

Such large-scale maps are accompanied by sections, small columns, and block diagrams. A sample of military-geological profile-column for underground mine laying is given in Fig 39.

In the composition of military-geological maps, first, the various existing cartographical materials are used, such as topographical, hydro-logical, soil, geological, hydrogeological, and engineering-geological materials, maps of useful minerals, road maps, maps of swamps, woods and vegetation, maps of various hydrotechnical processes (including water supply), military geographical materials, etc. Along with these materials much data can be successfully gained from published and archival accounts, reports, sketches, tables, all kinds of reference manuals, collected statistics, etc.

For example, in making up terrain-traversability maps it is possible to gather from large-scale (1: 25,000 and 1: 50,000) geographical maps all the necessary data on relief features, steepness of slopes, nature of marshes, and to some extent on rivers, lakes, fords, forests, roads, etc.

As a rule, however, this is not sufficient; hence, depending on the situation and given the possibility, it is almost always necessary to carry some field observation in order to gain the lacking information and to verify and correct the information on hand.

Under combat conditions, ground observation is often very difficult and it is necessary either to give up independent, specialized investigations or to combine them with engineering and front-line prospecting.

Under peacetime conditions, in the advance preparation of military geological maps, the mapping out of data required for the various specialized maps constitutes a component part of the complex, military-geological survey.

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Appendix

Table 38. Military-Geological Table for the  
Preparation of the Position before Stanislaw

[Reduced to outline form]

Loess or Clayey Soil Resembling Loess

Nature of Strata: Loess-Argillo-quartzitic, dusty soil with lime content, yellowish-brown color. Deposited on water divides in form of blanket deposit in veins up to 18 meters deep. Not found in valleys.

Clayey loess-like soil - loess having acquired properties of clayey soil. Impure (unclean). Sometimes more sandy, especially in valleys.

Workability: Easily workable with shovels.

Firmness: Good in dry weather. In wet weather, quickly deteriorates. Inclined to crumbling if trench walls are not reinforced with fascines.

Relation to Water: Water may be expected only in lower part of loess blanket deposit in plateaus; on slopes there generally is none. Loess is impermeable to water; clayey soil even less permeable.

Nature in Relation to Artillery and Mortar Fire: Tendency to break off vertically exerts harmful influence on resistance of trenches to pressure of detonations. Roadcover (TN: floors? overlapping?) of cave shelters easily crumbles if not reinforced by framework.

Condition of Trenches in Rainy Weather: Bad, if trenches are not reinforced with fascines and their floors not provided with grided flooring and drainage canals.

Organization of Cave shelters (Dugouts): Good shelters (dugouts) can be dug in loess on slopes and likewise on plateaus if low-lying, water-bearing strata are not reached. In passages through water-bearing strata, mine releases must be insulated.

Clay

Nature of Strata: Pre-eminently bluish, sometimes also greenish in color.

Workability: Processed with medium difficulty. Sticky in mountain gulches. A small gritty content.

Firmness: Bad in trenches. Trench walls must be reinforced against slipping. In cave shelters (dugouts) and tunnels very good if measures are taken against flow of water through entrances.

Relation to Water: Impervious to water. Only softens on top. Dry in the depths.

Nature in Relation to Artillery and Mortar Fire: Relatively good resistance.

Condition of Trenches in Rainy Weather: Very bad in the absence of effective water drainage.

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Organization of Cave Shelters (Dugouts): On clay foundation, cave shelters (dugouts), galleries, tunnels completely possible.

#### Gypsum

Nature of Strata: White, compact or granular rocky masses. Tendency to form lumps. Is distinguished by its softness (can be scratched with the fingernails) and its solubility in water.

Workability: Worked with difficulty (crowbar, blasting)

Firmness: Always good.

Relation to Water: Cracks and shell holes (araters) from bursts do not hold water. Water collects on the rock layer lying underneath the gypsum stratum.

Nature in Relation to Artillery and Mortar Fire: Probably possesses good resistance (firmness). In cases of steep walls, there is danger of fragmentation and formation of lumps.

Condition of Trenches in Rainy Weather: Good.

Organization of Cave Shelters (Dugouts): Data on this lacking up to present time. However, good cave shelters (dugouts) may be expected.

#### Detritus and Conglomerate

Nature of Strata: Crushed stone in mountains and conglomerate (gravel-stone) in valleys. The former presents itself in crumbly, the latter by deposits in present-day rivers and brooks. Chiefly hard Carpathian sandstone pebbles. A small amount of sand filler. Stones (boulders) reach a size larger than that of a head (especially in vicinity of the Carpathians).

Workability: Easily processed.

Firmness: Always bad.

Relation to Water: Often water-bearing. Digging trenches and cave shelters (dugouts) in detritus in mountains must be avoided.

Nature in Relation to Artillery and Mortar Fire: Very bad resistance. Disconnected boulders fragment off.

Condition of Trenches in Rainy Weather: Rainy weather does not exert great influence.

Organization of Cave Shelters (Dugouts): Generally not recommended in view of danger of influx of water.

#### Chalk

Nature of Strata: Porous, with small cracks.

Workability: Rather hard to work especially in mountain valleys.

Firmness: Good.

Relation to Water: There is only danger on level of subsoil water.

Nature in Relation to Artillery and Mortar Fire: Relatively favorable.

Condition of Trenches in Rainy Weather: Good, if grided flooring is

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provided and floor is kept clean of sludge (mud).

Organization of Cave Shelters (Dugouts): Chalk does not hold subsoil water; dugouts fully possible.

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